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Lean Manufacturing Analysis to Minimize Waste on The Production Process at CV. ABC

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Abstract

CV ABC is a manufacturing company engaged in fish processing. Currently, CV ABC is facing issues on its production floor. These issues are caused by the high frequency and abundance of various types of waste. The aim of this study is to identify and propose methods for minimizing waste in the production process through Lean Manufacturing analysis, specifically focusing on CV. ABC. Lean Manufacturing aims to continuously eliminate waste and enhance the value of products or services to meet customer needs. The primary objective is to pinpoint factors contributing to waste in production and suggest strategies for waste reduction. Both quantitative and qualitative data were collected, with 30 batches of fish roulade production serving as the basis for standard time calculations. The Lean Manufacturing Approach employed Value Stream Mapping to analyze information and material flow. The predominant wastes identified were waiting time during the steaming process, unnecessary movements, and non-compliant processes. To mitigate waiting time, additional production facilities were proposed to reduce dough wait times outside the steaming machine. Unnecessary movements could be minimized through increased supervision and firm action from management. Addressing non-compliant processes involved clarifying standard operating procedures and ensuring regular machine maintenance to uphold optimal performance. By implementing these improvements scenario, production lead time was reduced from 674.44 to 636.66 minutes.

A. Introduction

As industry competition intensifies, companies must strive for high competitiveness to outperform their rivals and ensure survival in the market. Achieving targets necessitates a smooth production process [1][2]. Efficient and effective operations are crucial for companies to meet consumer demand and enhance competitiveness [3][4].

To optimize production processes, minimizing waste is imperative as it hampers goal attainment and depletes resources [5]. Waste poses a significant setback as it diminishes effectiveness and efficiency, thereby eroding competitiveness [6]. Seven common types of waste often plague production processes, including defects, overproduction, waiting, transportation, inventory, motion, and excess processing [7][8][9]. Waste arises when non-value-added activities occur throughout the process flow [10], underscoring the importance of waste identification to enhance production process optimization and achieve effectiveness and efficiency [11].

In order to sustain and enhance profitability, it is essential to engage in thorough calculation and planning to remain competitive and foster growth [12]. Various factors influence a company's profit outcomes, with waste during the production process being one of them. Lean Manufacturing provides a suitable method for companies to assess levels of waste and mitigate non-value-added activities [13][14][15].

Through observations conducted by researchers at CV. ABC, it has been noted that several production activities are still not optimally effective, resulting in waste during the fulfillment of customer requests. These inefficiencies include production waiting time, manual transportation with limited loads leading to repetitive movements, and unnecessary motions such as searching for equipment during cleaning.

The production process at CV. ABC is encountering several challenges, particularly in the processing of fish roulade products, as it is relatively new and many current employees are still unfamiliar with the production channel. One notable issue identified in the production process is the waiting time during the steaming process. Factors contributing to this include limited machine capacity, inadequate machine preparation, and operators' lack of comprehension, leading to dough waiting for prolonged periods between steaming processes. This waiting time, ranging from 25 to 30 minutes and resulting in approximately one hour of overtime, is deemed problematic by the company and classified as a form of waste, specifically waiting. This type of waste occurs when workers are idle due to material shortages, process delays, equipment malfunctions, or bottlenecks, necessitating a comprehensive analysis and mapping of the entire production process. Utilizing the Value Stream Mapping approach can effectively map out the production process and identify potential waste hindering production efficiency.

The occurrence of such waste can lead to various problems. It is stated that activities lacking in added value within manufacturing companies can lead to inefficient resource utilization, resulting in increased production costs, decreased product quality, and prolonged production times [16]. One approach to address this issue is to adopt Lean Manufacturing, aiming to enhance production line efficiency. Lean Manufacturing comprises a series of integrated activities geared towards achieving maximum production output with minimal resource utilization, ultimately aiming to reduce process waste from suppliers to consumers [17]. Implementing Lean Manufacturing within industrial systems can improve work efficiency and effectiveness by scrutinizing non-value-added activities within a company [18]. This phenomenon is also reflected in the daily production outcomes, where significant differences in production quantities are observed, consequently impacting the company's profits. The total production figures for CV. ABC in the year 2023 are presented in Table 1.

Table 1. Amount Production CV. ABC Year 2023

Period	Results Production (Pcs)	Request (Pcs)	Scale of Demand (Pcs)
January	2,000	2,200	- 200
February	2,000	3,000 _	- 1 ,000
March	2,400	2. 8 00	-800
April	2,500	4,000	- 1,500 _
May	2,400 _	2,500 _	- 100
June	2.5 5 0	3,000 _	- 550

Hence, there is a necessity for enhancements aimed at eliminating or minimizing non-value-added activities that result in wastage through Lean Manufacturing analysis at CV. ABC. Lean Manufacturing constitutes a continuous endeavor to eradicate waste and enhance the value-added aspect of products or services, thereby delivering value to customers [19]. The Lean Manufacturing approach involves scrutinizing the flow of information and goods by employing the Value Stream Mapping method [20]. Value Stream Mapping serves as a methodology to depict and assess the complete material and information flow throughout the production process of a product within the company. Subsequently, conducting a Value Stream Mapping analysis facilitates the identification and comprehension of existing wasteful practices.

B. Research Method

The research was conducted at CV. ABC. The analysis was carried out from 2023 until sufficient data was obtained.

Variable Identification

The variables in this research are:

1. The independent variable is a variable that influences or is the cause of the change or emergence of the dependent variable or dependent variable [21]. The independent variables in this research are:
   a) *Waiting time*
   b) *Transportation*
   c) Unnecessary movement
2. The dependent variable is a variable that is influenced or is a result of the existence of an independent variable [21]. The dependent variable in this research are wastes.

Research Metodology

The reseach methodology following this step below:

1. *Current State Map Analysis*

The analysis for improving the current state map involves identifying existing waste, pinpointing the root causes of the problem, and devising strategies to address it.

2. Waste Analysis using *process activity mapping*

The objective of this analysis is to categorize all production process activities into either value-added or non-value-added activities. With this categorization in mind, a comparison between the time spent on value-added and non-value-added activities can be conducted. Subsequently, an assessment is necessary to identify potential improvements for each issue identified through the preceding analysis. The evaluation conducted in this study is outlined as follows.

3. Improvement scenario

The suggested enhancements to the production process stem from the analysis of the current state map and process activity mapping. Through this analysis, various issues regarding waste on the production floor have been identified. Consequently, proposals for improvements are deemed necessary to mitigate the occurrence of waste. The method employed in this section involves utilizing a cause and effect diagram with the 5W + 1H approach to offer recommendations for enhancements.

4. Planning *Future State Map*

The Future State Map outlines the envisioned state that the company aims to attain in the future.

C. Result and Discussion

Determination Time Standard

1. Cycle Time calculation

This is results of cycle time calculation on all over process production. Data from observations of the average cycle time for each process can seen on Table 2.

Table 2. Time Cycle Average Each Process

No	Process	Time Cycle (minute)
1	Milling	7.51
2	Mixing	13.84
3	Charging	2.69
4	Steaming	33.68
5	Draining	39.29
6	Freezing	480.00
7	Cutting	1.98
8	Packaging	14,19

In the freezing process, the processing time has been predetermined, eliminating the need for calculating the process time through the time study method. The subsequent section presents the outcomes of the data adequacy test calculations, normality data test, and uniformity data test across the entire process.

1) Data adequacy test
The Results of data adequacy test for every process can be seen on Table 3.

Table 3. Data adequacy test result

No	Process	Sampel Number (N)	Data adequacy number (N')	Exp.
1	Milling	30	19	Enough
2	Mixing	30	5	Enough
3	Charging	30	15	Enough
4	Steaming	30	21	Enough
5	Draining	30	8	Enough
6	Freezing	-	-	-
7	Cutting	30	6	Enough
8	Packaging	30	25	Enough

The results of the data adequacy test for each process indicate that the value of N > N', indicating satisfactory adequacy of the data. In the freezing process, no adequacy test calculation was performed as the freezing process time has already been established in the SOP, thereby eliminating any deviation in the process time.

2) Normality Test
According to the findings of the data normality test presented in Table 4, it can be inferred that the observation data for each process follows a normal distribution, as indicated by the significance level exceeding 0.05 for each process. In the freezing process, no data normality test was conducted as the process time has been predetermined in the SOP, ensuring a fixed processing time without any deviation.

Table 4. Normality Test Result

No	Process	Mark Sig	Information
1	Milling	0.272	Normal
2	Mixing	0.248	Normal
3	Charging	0.052	Normal
4	Steaming	0.053	Normal
5	Draining	0.580	Normal
6	Freezing	-	-
7	Cutting	0.102	Normal
8	Packaging	0.357	Normal

3) Uniformity Data Test
The outcomes of the data uniformity test are displayed in Table 5.

Table 5. Uniformity Data Test Result

No	Process	Std. Deviation	BKA	BKB	Description
1	Milling	0.83	9.18	5.85	Uniform
2	Mixing	0.82	15.48	12.20	Uniform
3	Charging	0.26	3.22	2.16	Uniform
4	Steaming	3.95	41.58	25.77	Uniform

5	Draining	2.80	44.89	33.69	Uniform
6	Freezing	-	-	-	-
7	Cutting	0.12	2.22	1.73	Uniform
8	Packaging	1.80	17.78	10.60	Uniform

In Table 5, it is evident that based on the results of the data uniformity test, all observed time cycle data are uniform throughout. This indicates that there are no data points that fall out of control or surpass the Upper Control Limit (UCL) and Lower Control Limit (LCL). For the freezing process, no uniformity test was conducted as the process time is predetermined in the SOP, ensuring no deviation in processing time.

Calculation of Normal Time And Time Raw

The results for the performance rating and allowance can be seen in Table 6.

Table 6. Performance Rating and Allowance Each Process

No	Process	Performance Ratings	Allowance (%)
1	Milling	1.13	16
2	Mixing	1.09	21
3	Charging	1.06	23
4	Steaming	1.11	25
5	Draining	1.08	18
6	Freezing	-	-
7	Cutting	1.14	12
8	Packaging	1.14	17

For the normal time calculation and standard time, the freezing process is excluded from the calculation as the freezing time has been pre-established in the SOP. The calculations are performed based on 10 kg of dough.

Table 7. Normal Time and Standard Time for Each Process

No	Process	Time Normal (minute)	Time Raw (minute)
1	Milling	8.49	9.84
2	Mixing	15.09	18.25
3	Charging	2.85	3.51
4	Steaming	37.38	46.73
5	Draining	42.43	50.07
6	Freezing	-	-
7	Cutting	2.26	2.53
8	Packaging	16,18	18.93

Current State

During the analysis phase of the current state map, activities in the fish roulade production value stream at CV. ABC were categorized. The table displays processes classified as value-added.

Table 8. Value Added Activity (VA)

No	Activity	Time (minute)
1	Grounding fish into Ground fish meat	9.84
2	Mixing and other ingredients	18.25
3	Putting the dough into plastic	3.51
4	Steaming	46.73
5	Cutting the roulade according to the designated time when it's already cooled	50.07
6	Freezing	480.00
7	Cutting in to into ready-to-eat sizes	2.53
8	Packaging	18.93
	Total	**629.86**

2. Waste Identification
   Based on the outcomes of interviews and questionnaire responses regarding waste occurrences during the production process, a summary of the questionnaire results is presented in Table 9.

Table 9. Recapitulation Questionnaire from 3 respondents

Waste	R1	R2	R3	Amount	Flat-Flat	Ranking
Overproduction	0	1	0	1	0.25	6
Defect	1	2	1	3	0.75	4
Unnecessary Inventory	0	1	1	2	0.50	5
Inappropriate Processing	1	4	1	6	1.50	3
Excessive Transportation	0	2	0	2	0.50	5
Waiting	3	2	3	8	2.00	1
Unnecessary Motion	2	3	2	7	1.75	2

According to Table 9, the summary of questionnaire results reveals that three types of waste are most commonly encountered in the production process. These include waiting time (waiting waste), unnecessary motion (movement waste), and inappropriate processing (process waste). Among these, waiting time emerges as the most prevalent waste based on the questionnaire findings. One effective approach for identifying the root causes of these wastes is to utilize a fishbone diagram, enabling targeted efforts to minimize their occurrence.

Inappropriate Process Waste processing

The waste resulting from processes not in accordance becomes the most significant waste observed during production at CV. ABC. Processes not being carried out accordingly may result in extended production times or the production of items that do not meet specifications. The fishbone diagram illustrating the causes of defective products, such as poor packaging, is depicted in Figure 1.

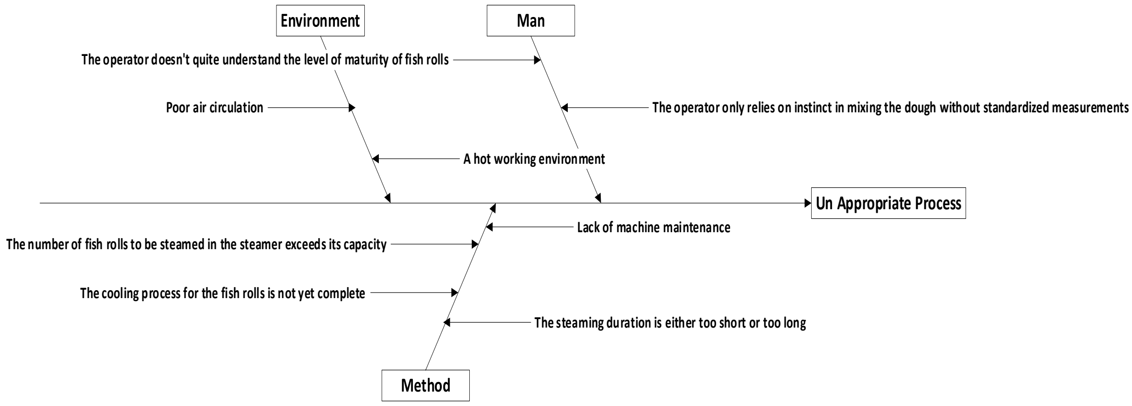

Figure 1. Fish Bones

***Value Stream Analysis Tools* (VALSAT)**

Based on the results of interviews and distribution of questionnaires about waste, so results from multiplication between waste weighting with the VALSAT matrix scale as well total for each VALSAT can seen on Table 10.

Table 10. Multiplication Waste Weight With Matrix VALSAT

Waste	***Process Activity Mapping***	***Supply Chain Respond Matrix***	***Product Variety Funnels***	***Quality Filter Mapping***	***Demand Amplication Mapping***	***Decision Points Analysis***	***Physical Structure***
Overproduction	0.25	0.75	0.00	0.25	0.75	0.75	0.00
Waiting	18.00	18.00	2.00	0.00	6.00	6.00	0.00
Transport	4.50	0.00	0.00	0.00	0.00	0.00	0.50
Inappropriate Process	13.50	0.00	4.50	1.50	0.00	1.50	0.00
Inventory	1.50	4.50	1.50	0.00	4.50	1.50	0.50
Unnecessary Motion	15.75	1.75	0.00	0.00	0.00	0.00	0.00
Defect	0.75	0.00	0.00	6.75	0.00	0.00	0.00
Amount	**54.25**	**25.00**	**8.00**	**8.50**	**11.25**	**9.75**	**1.00**

The multiplication of weight waste results with the VALSAT matrix indicates the selected VALSAT, which represents the process activity mapping with a total score of 54.25.

Future State Map Analysis

The identification and analysis of waste aim to reduce the time required in several stages of the process. Time reduction efforts are targeted at both the preparatory stage and during production. The activities within the production process that undergo process improvement are listed in Table 11.

Table 11. The Comparison between Before and After Improvement

No	Activity	Before (minute)	After (minute)
1	The operator retrieves the required gas for warehouse equipment.	2.61	2.61
2	The operator preheats the steamer.	12,14	12,14
3	The operator retrieves raw fish materials from the cooler cupboard.	5.77	5.77
4	Fish meat is milled.	9.84	9.84
5	The operator takes flour and spices from warehouse materials.	1.28	-
6	The operator weighs flour and spice additions.	1.17	-
7	Daily, the operator retrieves vegetables from the reception department.	1.27	1.27
8	The operator weighs the vegetables.	0.73	-
9	The operator retrieves the milled fish.	0.49	0.49
10	The operator weighs the required amount of fish.	0.83	0.83
11	The operator moves materials that are ready for processing to the mixing area.	0.13	0.13
12	Mixing the ingredients.	18.25	18.25
13	The operator moves the dough that is ready into a receptacle.	1.17	1.17
14	The operator moves the receptacle of dough to the charging area.	0.13	0.13
15	The operator prepares the machine for charging.	2.21	2.21
16	The operator fills the machine with dough.	1.23	1.23
17	Fish-filled dough is rolled into plastic.	3.51	3.51
18	The operator rinses the packaged dough with water.	0.41	0.41
19	Packaging is assembled on trays for steaming.	0.27	-
20	The operator moves the tray to the steaming area.	0.17	0.17
21	The tray is placed into the steamer machine.	0.56	0.56
22	Steaming the fish-filled dough.	46.73	46.73
23	The operator checks the maturity of the Roulade.	1.21	1.21
24	The operator removes the tray from the steamer machine.	0.56	0.56
25	Roulade is transferred from the steaming tray to a draining tray.	0.61	0.61
26	The operator arranges the Roulade on the draining tray.	0.95	-
27	The operator removes the plastic wrapping from the Roulade.	1.29	1.29
28	The draining tray is moved to the draining process area.	0.18	0.18
29	The ripe Roulade is drained to lower its temperature.	50.07	16.69
30	The operator checks the temperature of the Roulade.	0.30	0.30
31	The Roulade is moved to the freezing process.	0.45	0.45
32	Freezing the Roulade.	480.00	480.00
33	The operator retrieves the Roulade from the cooler cupboard.	0.45	0.45
34	The operator removes all plastic wrapping from the Roulade.	0.94	0.94
35	The Roulade is moved to the cutting process.	0.19	0.19
36	The operator prepares the cutting machine.	2.09	2.09
37	Roulade is arranged on the cutting table.	0.44	0.44
38	The fish Roulade is cut into pieces.	2.53	2.53
39	The results of cutting Roulade are moved to the packaging	0.19	0.19

	process.		
40	The operator retrieves packaging and cardboard boxes from the packaging warehouse.	0.35	0.35
41	The operator prepares the packaging machine.	1.63	1.63
42	Packaging is done for Roulade in 500 gr packaging and placed inside.	18.93	18.93
43	Cardboard boxes are placed inside the cooler cupboard.	0.18	0.18
	Total *Leads Time*	674.44	636.66

According to the data in Table 11, the activities with potential time reductions to decrease lead time include:
- Time spent on taking flour and adding spices, totaling 1.28 minutes.
- Time spent on weighing flour and adding materials, totaling 1.17 minutes.
- Time spent on weighing vegetables, amounting to 0.73 minutes.

These activities can potentially be combined, specifically during the process of taking and weighing. Additionally, this aims to alleviate operator workload to prevent repetitive tasks. These minimization efforts were determined after discussions with relevant company personnel regarding the processes that could be streamlined. It's noted that the removal of certain processes will not adversely affect subsequent processes.

Moreover, the time taken for packaging arrangement on the steaming tray is 0.27 minutes, while the preparation time for roulades in the draining tray is 0.95 minutes. These activities can be performed sequentially after washing and transferring to the draining tray, or by not stacking them initially to simplify the process.

Furthermore, there's potential for time reduction in the draining process, which currently takes 50.07 minutes. By adding two additional fan units, assuming their performance matches the existing unit, the draining process could be accelerated threefold. This suggests an estimated time for draining of 16.69 minutes, resulting in a reduction of 33.38 minutes from the original time. These analyses have led to a reduction of 37.78 minutes in production lead time, resulting in a decrease from 674.44 minutes to 636.66 minutes.

Recommendation

Recommendation for waiting time

Based on the identification of waste, it has been observed that waiting time occurs during the steaming process. Recommendations to address waiting time during the steaming process includes:

1. Ensuring that the machine steamer is preheated at the beginning or before the start of production for each production process.
2. Maintaining a minimum reserve of two gas cylinders in storage warehouses to ensure continuous availability in case of any issues during the production process.
3. Implementing clear indicators for the maturity level of the fish roulade to facilitate inspection by operators, ensuring that steaming does not occur for excessive durations.
4. Strengthening supervision of operators during the steaming process to prevent issues such as gas cylinder depletion or excessively long or fast steaming.

5. Increasing the capacity of steaming by adding an additional steamer machine, which can reduce waiting time for dough readiness outside the steamer. Additionally, ensuring sufficient availability of draining trays, approximately 300 units, can support the production process when additional steamer machines are introduced.

Recommendation for unnecessary movement

Recommendation for unnecessary movement waste identified in the production process, the following recommendations are proposed:

1. Increase supervision by superiors or foremen during the production process to minimize unnecessary interactions between operators.
2. Implement firm actions against operators engaging in potentially unnecessary tasks that prolong production time.
3. Provide more detailed explanations about the tasks assigned to each operator, ensuring clarity to minimize unnecessary movements.
4. Improve air circulation in the work area to reduce overheating, which can be achieved by installing additional ventilation or air conditioning systems such as fans or water coolers. Additionally, reevaluate the work posture of operators who are required to stand throughout the entire process, considering the implementation of ergonomic seated positions to enhance the efficiency of the production process.

Recommendations for Overprocessing

Based on the identification of over processing waste, the following recommendations are proposed:

1. Implement clear indicators for the maturity level of the fish roulade to facilitate inspection by operators, ensuring that the steaming process is neither too prolonged nor too rapid.
2. Increase supervision by superiors or foremen during the production process to ensure that operators adhere to the standard operating procedures established by the company.
3. Provide clearer Standard Operating Procedures (SOPs) for every production process and ensure their integration into each step of the production process to minimize deviations by operators.
4. Conduct regular checks and maintenance on production machinery, such as mixing machines, and ensure the availability of essential supplies such as gas cylinders to prevent interruptions in the steaming process during production.
5. Improve air circulation in the work area to prevent overheating, possibly by installing additional ventilation or air conditioning units such as fans or water coolers. Additionally, reassess the working posture of operators who are required to stand throughout the entire process and consider implementing ergonomic seating arrangements to optimize the production process.

D. Conclusion

The predominant waste identified includes waiting time, unnecessary movements, and non-compliant processes. Waiting time waste primarily occurs during the steaming process, while unnecessary movements occur throughout the production process due to operators being unfocused and engaging in conversations with others. Non-compliant process waste is more prevalent during steaming, mixing, and cutting processes, often because operators rely on their judgment for dosages and lack clear standard operating procedures. Insufficient maintenance of machinery also contributes to process inefficiencies.

To minimize waiting time waste, additional production facilities can be added to reduce dough waiting outside the steaming machine. Unnecessary movements can be reduced through increased supervision and firm action from superiors, along with improvements to the work environment for enhanced comfort. Non-compliant process waste can be mitigated by clarifying and enforcing standard operating procedures across all production processes, as well as implementing regular maintenance schedules to ensure machinery operates optimally. By reducing these wastes, the lead time can be decreased by 37.78 minutes, resulting in a total production lead time reduction from 674.44 minutes to 636.66 minutes.

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